OCCASION

This publication has been made available to the public on the occasion of the 50th anniversary of the United Nations Industrial Development Organisation.

DISCLAIMER

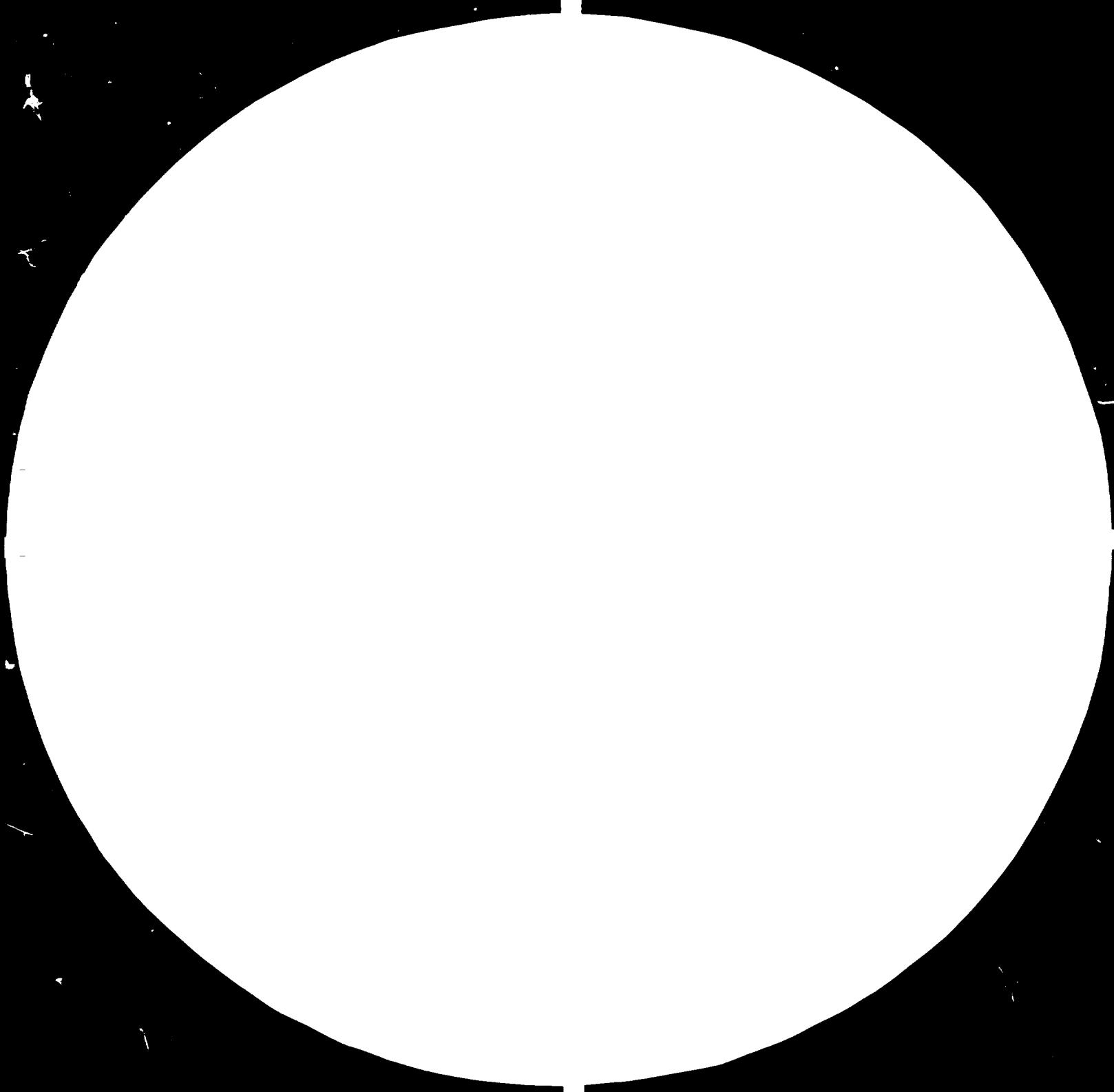
FAIR USE POLICY

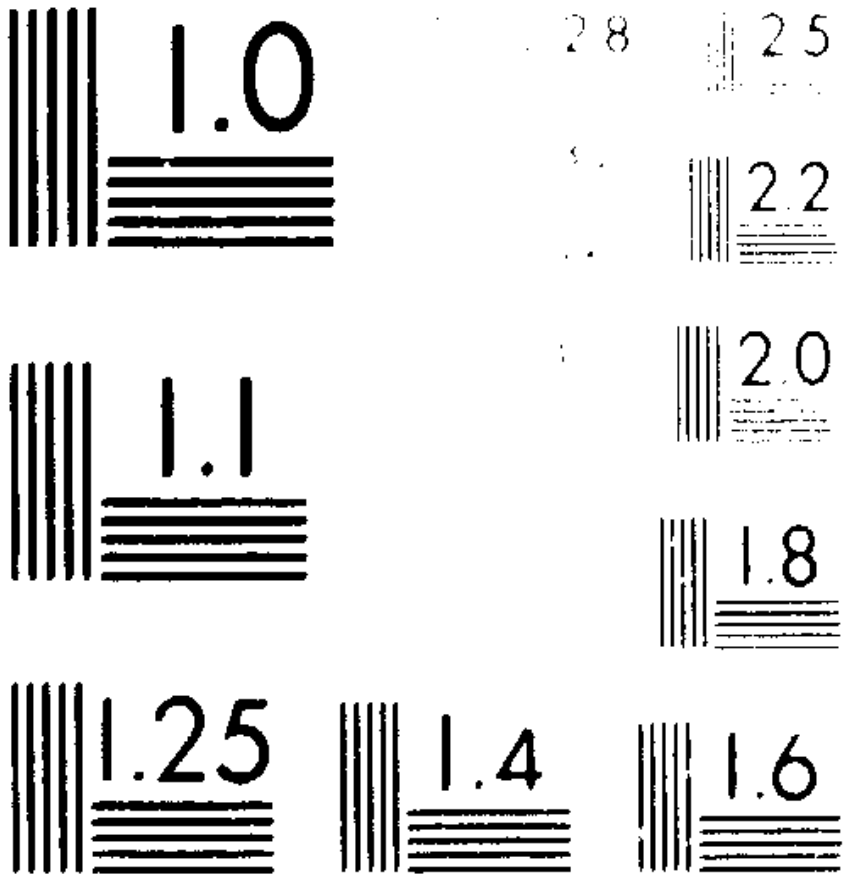
CONTACT

Please contact publications@unido.org for further information concerning UNIDO publications.

For more information about UNIDO, please visit us at www.unido.org

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org




2.8
2.5
1.0
2.2
2.0
1.1
1.8
1.25
1.4
1.6

DP/ID/SER.A/309
11 August 1981
ENGLISH
Original: ITALIAN

RESTRICTED

10869

EXPERT SERVICES AND FELLOWSHIPS FOR BUILDING MATERIALS AND NON-METALLIC MINERALS

DP/CPR/79/019

CHINA

Technical report: Marble processing in Shanghai*.

Prepared for the Government of China by
the United Nations Industrial Development Organization,
acting as executing agency for the United Nations Development Programme

Based on the work of Luigi Maccai,
expert in marble and granite processing

United Nations Industrial Development Organization
Vienna

* This document has been reproduced without formal editing.

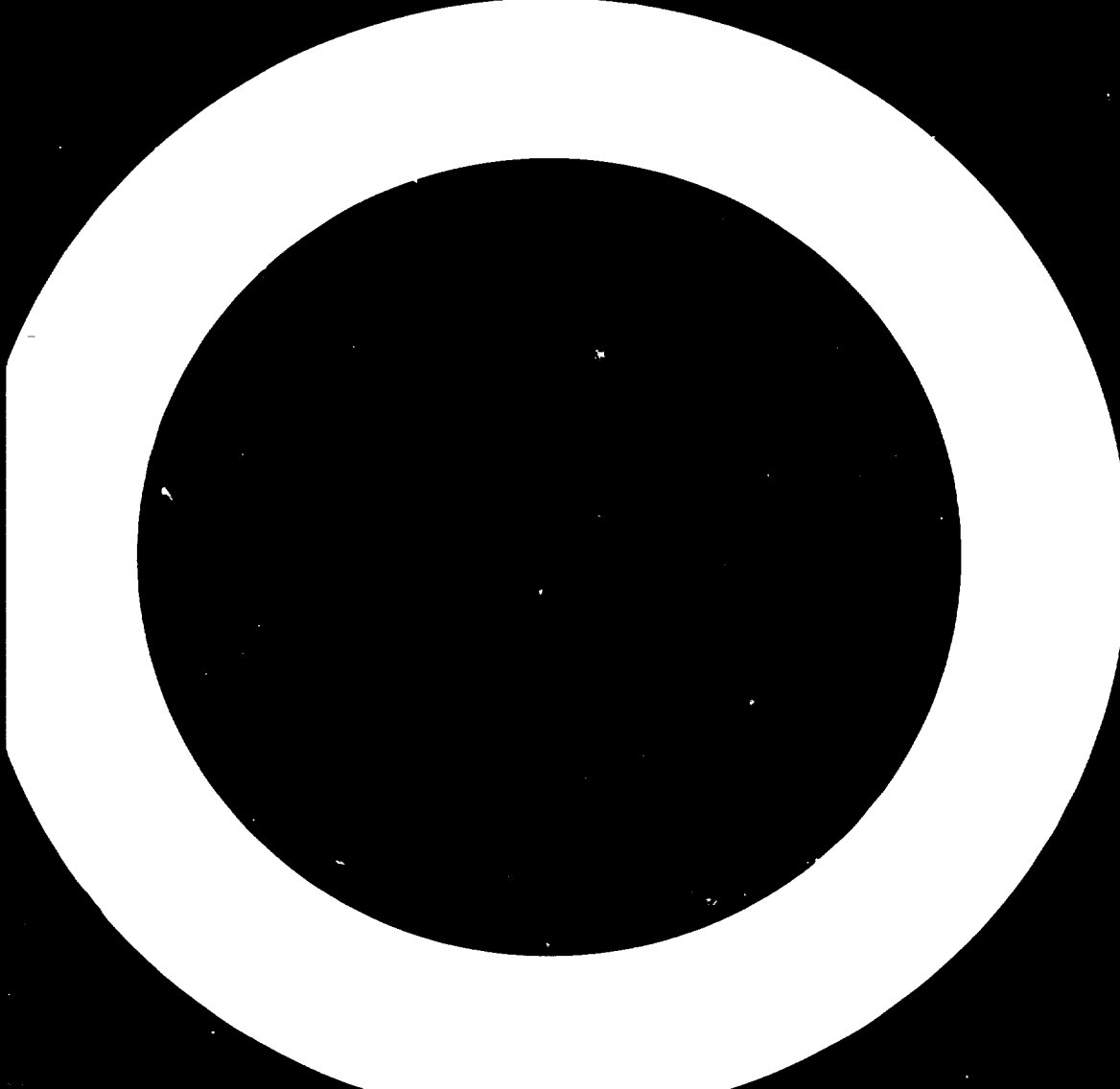
V.81-28504

Mention of firm names and commercial products does not imply the endorsement of the United Nations Industrial Development Organization (UNIDO).

ABSTRACT

As part of the project of the United Nations Development Programme (UNDP) "Expert Services and fellowships for building materials and non-metallic minerals" (DP/CPR/79/019) for which the United Nations Industrial Organization (UNIDO) is acting as the executing agency, an expert in marble and granite processing was sent on a mission of three weeks, starting on 15 March 1981.

The expert's work programme was divided into three phases. The first studied and assessed the equipment in use at the Shanghai plant and received technical inquiries submitted by the factory management. During the second phase the expert presented in the mornings lectures on technical problems involved in the working of marble, on equipment, techniques and methods to improve the quality of the finished product. The afternoons were devoted to discussions of the subjects touched on in the morning sessions. In the last phase two production units, one for traditional processing and the other for the working of very thin marble, were designed in co-operation with the directors of the Shanghai plant.



Contents

INTRODUCTION

As part of the project of the United Nations Development Programme (UNDP) "Expert services and fellowships for building materials and non-metallic minerals" (DP/CPR/79/019) for which the United Nations Industrial Development Organization (UNIDO) is acting as the executing agency, an expert in marble and granite processing was sent on a mission of three weeks, starting on 15 March 1981.

The expert was requested by UNIDO to serve on an assignment designed to raise the level of technological competence in marble processing at production units in Hangzhou and Shanghai. More specifically, his assignment consisted in:

- Explaining the most modern and advanced techniques;
- Advising on processing technologies;
- Advising on the use of diamond tools and grinding agents;
- Advising on a modern management and planning approach to the processing of marble.

Following the expert's arrival at Beijing, during his first meeting with officials of the Ministry of Building Materials, he received in written form the Ministry's detailed requests regarding the objectives he was to pursue in his work. On the basis of this material, a plan of work for completion during his assignment in China was prepared.

This programme contemplated the following three phases:

Phase one

(a) Visit to the Shanghai plant, the study of the equipment in use there, and the submission of technical inquiries by the factory management;

(b) Presentation by the expert of a review of the international situation with respect to production, technical and commercial factors, and present-day development technologies in the marble processing sector.

Phase two

Presentation and study of the technical problems involved in the working of marble, the equipment in use or recommended for use, the techniques for working marble of large dimensions and fine thickness, methods for improving the working of the material and the quality of the finished product.

Phase three

Planning of a restructuring of the Shanghai plant and of a production line for thin slabs; evaluation of the results of the co-operation between the two parties.

The time-table of events followed in this mission to China was as follows:

16-17 March

In Beijing, discussion with officials of the Ministry of Building Materials and preparation of the programme; visit to the UNIDO Office to meet the officials in charge of the project.

18-19 March

In Shanghai, first contacts with the local authorities and the directors of the Shanghai plant; initial discussions regarding the objectives of the mission; visit to the Shanghai plant and meetings there with directors and supervisory personnel from Shanghai and Hangzhou for the purpose of determining the programme to be followed during the afternoons set aside for discussion at the plant.

20-27 March

In Shanghai, implementation of phase two of the programme, namely:

- In the morning, lecturing to about 60 people;
- In the afternoon, discussion of the subjects touched on during the morning with Mr. Liao and the directors of the Shanghai plant plus a number of senior officials from the Hangzhou plant.

28-31 March

In co-operation with the directors of the Shanghai plant, design of two production units: one for traditional processing and the other for the working of very thin marble. At the conclusion, final discussions to evaluate the results of the mission.

1 April

Departure for Beijing.

2 April

Talks in Beijing with Ministry officials on evaluating the possibilities for expanding the planning of the two proposed production units.

3 April

Briefing of Mr. Leither at the UNIDO Office on the results of the mission and its possible and planned further stages.

4 April

Leave-taking and departure from Beijing and China.

I. THE SHANGHAI PLANT

The main objective which the Chinese authorities wished to achieve through the mission was to secure the opinion of an expert on all phases in the processing of marble, with particular reference to the operations

of the Shanghai plant.

In fact, as the first matter of business following the expert's arrival in Shanghai, he was immediately taken on a tour of the plant, which was explained to him in great detail. In the discussion that follows, this plant will be described, which, according to information received, is the largest anywhere in China.

The plant employs 630 persons, 54 of whom work in the administrative and technical offices, with the remaining personnel assigned to the processing, maintenance and transport departments.

All told, the plant occupies an area of 30,000 square metres, of which some 17,000 m^2 are enclosed, including 7,000 m^2 for actual production operations, 4,000 m^2 for secondary sections, and the remaining area for use as office space and other purposes.

The work is organized as follows:

Sawing: There are 16 sawing machines, 13 of which are in use. These machines, except for one which is experimental and not currently in operation, are of the traditional type using sand and steel filings and are employed for both marble and granite. A characteristic of these sawing machines is that they are very

small - designed, that is, for the kind of blocks which are obtained from the Chinese quarries.

Slab squaring: There are seven cutting machines, one of which, currently being installed, is a bridge cutter; of the others, which are cutters with template support arms, a number are used to produce marble for electrical control panels and instruments.

Polishing of the slabs and custom-cut work: There are:

- 9 grapples;
- 3 bridge-type polishing machines, one of which is in operation;
- 13 rotary-hand polishing machines, of average size;
- 13 polishing machines of the same type as above but smaller.

According to information furnished by the plant management, the plant has a production capacity of 80,000-100,000 m^2 a year. This figure is based on an average of 306 working days a year.

The layout of the plant is as follows:

Coming from the outside one enters a vast court served by a 20-tonne gantry crane which is used for the off-loading of the blocks and the positioning of the saw carriages.

The sawing operations building is situated parallel to the run of the gantry crane, the saws being aligned perpendicular to the length of the shed. The same saws are used for both marble and granite and employ silicious sand and metal filings. The slabs received from the sawing area are subsequently processed in two different ways:

(a) They are first cut to measure by a twin-band milling cutter and then polished; or

(b) They are first polished by a bridge polisher or hand polishers, after which they are cut to measure.

There is a separate section where, using rather old but reasonably efficient equipment, pieces are produced for electrical control panels and apparatus.

It is of interest to consider the types of marble available to the plant:

- The nearest quarry, at Ichin, yields a coffee- or beige-coloured marble which can be easily worked but is rather defective because of its fairly pronounced stratification and small lithoclases.

- The Chang-Su quarry supplies the plant with blocks of a very beautiful reddish-coloured marble of relatively easy workability. Fairly free of defects, this marble can be processed in a variety of ways.
- The Han-Huai quarry yields a milky marble similar to that obtained at Ichin.
- The Hangzhou quarry yields a lighter or darker grey marble which, though quite attractive, is seriously flawed because of its marked stratification and fine fissuring.
- A very beautiful black marble, but always in small blocks, is recovered from the quarry of the Gui Lin plant.
- Finally, the Shen-Dun quarry produces a crystalline white marble, of slightly coarser graininess than a Carrara but with similar characteristics. This marble is of excellent workability and could be used to increase the production capacity of the plant. At present, it is used mainly for the production of electrical control panels and other electrical equipment.

Plant productivity is greatly affected by the type of marble worked and also by the manner of processing.

By way of information, I was given the following data on average finished-product yields for the different types of marble worked:

Hangzhou marble	12 m^2	per cm^2	of thickness	per m^3	in block form
Han-Huai marble	15 m^2	"	"	"	"
Ichin marble	12 m^2	"	"	"	"
Shen-Dun marble	23 m^2	"	"	"	"

It is immediately clear from these data that the average yield is in any case very low. The fact is that the normal working of marble in Europe produces far higher yields - as much as 30-32 m^2 of finished product per cm^2 of thickness for every m^3 of raw material.

On the basis of my initial survey of the Shanghai plant, a number of considerations and suggestions immediately present themselves:

1. The blocks of raw material available to the plant are too small for modern processing. The machinery was designed for the size of the blocks available, with the result that it too is poorly suited to modern working techniques. The lack of sufficiently large blocks is the plant's

most serious deficiency and makes the improvement of production very difficult.

2. The performance of the sawing section is technically very poor. for one thing, the sawing is performed too quickly, resulting in cut surfaces t at are not perfectly flat, so that the slabs are subsequently difficult to work. Secondly, the blocks are not sawn all the way to the end, so that, at best, the lower part of the slabs differs in thickness from the rest, a circumstance which, in addition to making it easier for the piece to split, renders subsequent effective processing impossible. The poor performance of the sawing section negatively affects all the remaining processing phases.

3. In unloading the slabs from the saw carriages, the necessary precautions are not taken; many slabs that might otherwise be used for a variety of applications are broken at this point.

4. The use of steel filings together with silicious sand for the sawing of the marble cannot be regarded as a sound practice in the light of the subsequent processing intended. The fact is that, even when the

cutting speed is sufficiently high, sawing with filings makes for a very uneven slab surface, so that the subsequent polishing operation becomes very time-consuming and difficult. In addition to the poor flatness of slabs sawn in this way, this is the major cause of the jamming of the bridge polishing machines used at the plant, since these machines are designed for use with more even-surfaced materials.

5. The cutting department is relatively well designed; operations, even if not very modern, are adequate to the needs of the plant. The twin-band milling cutter produces tiles of the standard sizes (30 x 30, 60 x 30, 40 x 40 and 60 x 90 cm) and is capable of performing reasonably well the job for which it was designed.

6. The polishing department is largely very primitive. A [illegible] r of the machines should be replaced by more modern models, and automatic polishing machines should be used, particularly for the standard sizes. Nevertheless, the department performs quite well, and the finished product is of acceptable quality.

7. In the finishing and packaging department there are many things that could be improved. First of all, thought should be given to the

standardization of the packaging so as to systematize the work of the warehouse and the arrangement of the finished products in the storage areas. For example, by using crates with the same square-metre content of marble, regardless of size, the handling of the various orders could be greatly facilitated.

One problem connected with finishing and storage is the problem of the movement of the marble within the plant. In this area, there are many improvements that might be made to the present arrangements. The greatest shortcomings occur in the transport of the slabs and semi-finished products between the different processing areas. Quite often, the products in process spend too much time moving from one department to another at the expense of efficient operation and thus of the productivity of the plant itself.

All these problems were fully discussed with the managers and technical staff of the Shanghai plant during the afternoon talks scheduled for this purpose. During these talks the expert found a keen awareness of these problems on the part of the plant representatives, and he came away with the impression that the discussions themselves were highly constructive. The talks dealt

with specific practical matters in an effort to bring to bear, as effectively as possible, my specialized expertise in Western techniques and approaches.

The expert also endeavoured to study the possibility of using the saws already installed at the plant according to Western methods. To this end, he spent an entire afternoon observing the loading and operation of a sawing machine in order to suggest ways of improving sawing performance using sand. This effort was at least partially successful, thus demonstrating that by calling on various kinds of experience, improvements in processing quality can be rapidly achieved.

Another subject which was discussed in detail during the afternoon talks was the matter of practical plant management along Western lines, including the relationships between the plant and the quarries, the various suppliers, and foreign markets.

The expert believes that these afternoon discussions with the management and technical staff of the plant were very useful, principally because, as there are relatively few marble production units in China (and those that do exist differ widely one from the other), exchanges of experience are far more difficult than in Italy, where there are large associations of marble producers.

II. SUMMARY OF THE SUBJECTS DISCUSSED IN THE LECTURES DELIVERED FROM 20 TO 27 MARCH

The expert was expressly requested to deliver a series of technical lectures according to a programme prepared on 16 and 17 March in Beijing with Ministry officials.

This programme was carried out as follows:

First lecture, 20 March

- Survey of the international production of marble, with particular reference to:
  - Product classification;
  - Standards required by international markets for various types of products, such as blocks, unfinished slabs, and finished products ready for use, such as various types and formats of tiling, various types and formats of internal cladding, external cladding, and products and accessories for interior decoration.
- Survey of the international marble market and classification of the various countries as between marble producers and importers, or importers and exporters.

Second lecture, 21 March

- Examination of the international market, with particular attention to the classification of buyers according to their specific requirements; analysis of sales possibilities for various products in various markets. Analysis of the types of marble most sold in the various markets and of their similarities to Chinese marbles.
- Survey of the Italian market; analysis of the products available from this market and of export-import trading of all stone materials in Italy.
- Analysis of Italian marble export trends based on statistics co··ing the period from 1975 to 1979.
- Survey of the Italian marble industry, with presentation of statistical information on the number of workers and size of the production units, and with particular attention to the latest trends at the new plants. Analysis of current trends towards the installation of diamond-bladed automatic saws and other preliminary processing machinery.

Third lecture, 23 March

Examination of preliminary marble sawing operations.

- Selection of equipment as a function of the type of material to be worked and the type of product to be produced.
- Detailed analysis and illustration of the various kinds of machines available on the international market, such as:

  Sawing machines, diamond-bladed, horizontal or vertical, with descending or fixed blade-carrier, open or closed, fast or slow.
- Design specifications and operational characteristics of the different machines.
- Classification of the various marble types as a function of their working ability and the use of particular machines.
- Types of diamond-studded saw blades for use with different types of marble.
- Recommended power as a function of various parameters, such as travel speed, varieties of material, and equipment types; analysis of theoretical tables and practical results.

- Blade mounting systems and the correct use of diamond-bladed sawing machines.
- Detailed analysis and illustration of orthogonal block-cutting machines, with particular attention to the recommended use of the different types as a function of the particular kind of processing desired, the type of marble to be worked, and the types of blocks available; examination of the diamond-studded discs designed for orthogonal cutting machines and the criteria governing their selection; various methods for the practical use of these cutting machines.

Fourth lecture, 24 March

Examination of the operations of the custom-cutting and polishing of slabs and intermediate products, using preliminary cutting machinery.

- Analysis of the custom-cutting equipment available on the market, such as bridge, band and template support arm cutters.
- Criteria for the selection of equipment, and practical methods of use.

Examination of the operations concerned with the polishing of the slabs. Analysis of the existing machines, and of the criteria governing their selection and use. Criteria governing the selection of the abrasives to be used depending on the type of machine, the material to be worked, and the desired hourly production rate. Analysis of whetstone shape for rational use, and observations on the composition of the whetstone.

Fifth lecture, 25 March

Examination of the possible equipment layouts in a modern marble production unit operating according to traditional methods. Analysis of a number of standard arrangements, interdependence between the various types of machinery, and study of the rational movement of the material within the plant.

- Examination of internal conveyance facilities in a modern marble plant.

Analysis of the principal machines used, such as:

- Overhead travelling cranes;
- Self-propelled cranes;
- Lift carriages;

- Small accessory devices.

Analysis of accessory devices for lifting and transport, such as vacuum stone lifts, special containers, and standard and custom packaging for in-plant use.

Sixth lecture, 26 March

Analysis of the working of thin slabs.

- Classification of products and the specific characteristics which products must possess in order to qualify in Italy for the designation "MODULMARMO". Standard dimensions and standard packaging.
- Examination of the different systems for producing thin slabs and of the different machines required. Use of traditional machines and of specially designed equipment for the processes in question. Criteria for the selection of various technical approaches depending on the materials used and the formats and product types desired.

Seventh lecture, 27 March

Use of waste materials; treatment of waste water and its recycling.

Use of wastes for the production of marble granulate, flooring materials,

and marmoresina slabs. Analysis of the different techniques and equipment required for the production of these products.

Analysis of a standard waste-water cleansing facility using modern reclamation techniques; waste water recycling.

- Observations on European methods of marble plant management.

  Discussion of typical plant functions; analysis of various functions and relationships between plant officials.

Example of the practical management of a medium-sized marble production unit. Possible foreign contacts and relationships of a marble enterprise.

III. RESTRUCTURING OF THE SHANGHAI PLANT

Following the completion of the technical lectures and the afternoon discussions with the management and technical staff of the Shanghai and Hangzhou marble plants, there was provision for a third phase during which two facilities were to be designed: the first for the working of marble in the form of large slabs and traditional processing; the second for the working of thin slabs.

The planning of these facilities required three days, during which, together with his Chinese colleagues, the expert examined the various possibilities of using the equipment in a manner consistent with conditions as they exist in China.

Let us examine in greater detail the work carried out and, in particular, the reasons which prompted me to prefer certain approaches to others.

Facility for the working of large-sized slabs

The expert was requested to design a facility capable of producing 100,000 m^2 a month of bright-surfaced finished products of 2 and 3 cm thickness for use as flooring, cladding, stairs, etc., together with a number of accessory processes as requested.

A first and very important observation that should be made is that, according to what the expert was told and was able to see for himself, the blocks available in China are very small. Using blocks of this kind it is impossible to achieve acceptable yields with modern machinery, which require blocks of larger size. A necessary condition, therefore, for any kind of modern plant is the availability from the quarries of blocks averaging 3 m^3 in dimensions.

In discussions with the management officials and technicians of the plants the expert raised this question on more than one occasion. As far as he was able to determine, it appears that the limited size of the blocks is due not to any quarry-related factor, but to problems of transportation. In other words, the various marble and stone deposits in China actually are capable of furnishing large-sized blocks, with recovery possible using the excavation techniques currently in use, but it would not be possible to haul these blocks to the plants.

In fact, certain of the quarries are many hundreds and, in some cases, even thousands of kilometres away from the plants, the blocks being brought in over these distances by a variety of transport facilities, such as trucks, rail cars, and on occasion even river boats.

On one trip the expert visited the quarries in the vicinity of the Hangzhou plant. At these sites there are major marble deposits which could in fact be worked to produce large blocks with no substantial changes in the excavation techniques.

On these assumptions and regarding it therefore as possible to supply the Shanghai plant with blocks of sufficient size, together with the technicians of that plant the expert designed a facility having the following characteristics and equipment.

For the first phase, namely the cutting of the blocks into slabs, following a careful examination of the equipment installed in the plant, its working characteristics, and structure, the use of three slow-action diamond-bladed sawing machines was suggested, which would thus be capable of sawing materials of all types, even if somewhat defective.

These three sawing machines, of 50 or 70 blades, to be selected from among the models currently on the market, could each, if operated over a period of 16 hours, produce some 50,000 m^2 of 2-cm slabs or 35,000 m^2 of 3-cm slabs a year for use as stairs or wall cladding.

In this way, assuming that one saw were used to produce 3-cm slabs and two saws to produce 2-cm slabs, the production capacity should amount to about

135,000 m^2 of slabs a year, an amount which, allowing for finishing losses, should easily yield nearly 100,000 m^2 of finished product.

This calculation is based on a working schedule of 16 hours for 20 days a month over 11.2 working months. In the event that it were decided to operate the saws around the clock and to increase the number of annual working days, the number of saws might be reduced from three to two. The production capacity, in this case, would be almost the same, but with a substantial saving in the purchase of equipment. On the other hand, the entire facility would be exposed to the risk of possible production stoppages because of mechanical failures, which are always possible. In addition, periodic maintenance would have to be very well planned so as to avoid problems.

The need for raw marble blocks can be put at about 4,000 m^3 a year.

After the blocks have been sawn into slabs, the idea is to divide the subsequent phases into two distinct parallel equipment lines or sequences. The layout envisaged can be better seen in the diagram given in annex II.

The first line consists of the following equipment:

- One bridge polishing machine for unfinished slabs;

- Two bridge cutters for cutting the slabs to measure;
- One continuous-cycle polishing machine with a working width of 60 cm.

The other line consists of:

- One bridge cutter for cutting the slabs to measure;
- One continuous-cycle polishing machine with a working width of up to 40 cm;
- One edge-polishing machine.

Certain of the machines, specifically the bridge polishers and the bridge cutter, are already in place at the Shanghai plant, their condition being such that they could easily be modified and made operational.

In this connection, it is recommended that at least some of the new machines be purchased from the Gregori company, which produces the two machines in question, in order to have available the services of the technicians whom the company would send out to see to the proper installation of the new equipment.

The two production lines would be operated as follows:

- Line one would be reserved for the working of slabs 2 cm thick to produce rectangular and square finished products for use as flooring and cladding.

  A continuous-cycle polishing machine with a working width of up to 60 cm has been provided in order to afford the possibility of polishing slabs measuring up to 60 x 90 cm, this being the largest size normally required for cladding. For larger work, at the beginning of the line there is to be a bridge polishing machine designed to work with slabs received immediately from the sawing operation. In this case, the slabs are cut to measure after they have been polished.

- Line two, on the other hand, is essentially designed for producing slabs with a thickness of 3 cm or more for use as stairwell cladding, window-sills, jambs, door mouldings, etc.

  This line is to have a continuous-cycle polishing machine with a working width of 40 cm, since the products mentioned

are almost never wider than that. In the case of widths of between 40 and 60 cm, the pieces can be worked on the other polisher, or else the bridge polisher, which has a working width of more than 60 cm, may be used.

Following the polisher, the edge-polishing machine is used for refinishing the pieces and for the various kinds of additional processing requested.

The entire laboratory is served by a five-tonne travelling crane capable of shifting even the heavy carriages between the various machines. For the in-plant handling of the pieces, the use of a fork-lift is recommended; in addition to being both faster and more manoeuvrable than an overhead crane, a fork-lift offers the advantage of being able to operate outside the plant as well.

The energy requirements of the plant described above are as follows:

Three 60-blade sawing machines	360 hp
One bridge-type polishing machine	30 hp
Three bridge-type cutting machines	105 hp

One continuous-cycle polishing machine, 60 cm	80 hp
One continuous-cycle polishing machine, 40 cm	60 hp
One edge-polishing machine	30 hp
One crane	25 hp
Small machines	30 hp
Approximate total	690 hp

The labour requirement may be calculated as follows:

Three sawing machines in two shifts	4 workers
One bridge-type polishing machine	1 worker
Three bridge-type cutting machines	6 workers
One continuous-cycle polishing machine, 40 cm	2 workers
One continuous-cycle polishing machine, 60 cm	2 workers
One edge-polishing machine	1 worker
One overhead travelling crane	3 workers
One lift carriage	1 worker
Total work-force	20 workers

(One plant foreman may be added to this number.)

The production capacity should be about 100,000 m^2 a year, which at an ex works price of about $US 20-25 per m^2 would represent annual billing of approximately 2 million to 2.5 million dollars a year.

Planning of a thin-marble production line

As the final phase of his mission in China, the expert was asked to plan a facility designed to produce thin marble tiles.

In this type of production, modern technological means are used to produce small tiles which are thin enough to be gluable using modern glues, thereby permitting a major saving of labour in their installation.

Following a study of the Chinese materials available for processing in Shanghai, the production line was planned as follows (with respect to the principal machines):

One orthogonal cutting machine

One automatic device for unloading the blocks

One squaring machine

One splitting machine

One polishing machine

One squaring machine

One gauging and chamfering machine

plus the various required linkages between the different machines.

Reference has been made to a production line available from the Gregori company, which is very well designed and includes all the mechanical linkages connecting the various equipment units. Moreover, this line can produce the tile sizes in greatest demand, i.e., 15 x 30 x 0.7 and 30 x 30 x 1.0 cm.

In any event, it is recommended that, if this line is adopted, the sequence suggested above, and not the one proposed by the manufacturer, should be respected.

The fact is that when working with low-strength marbles like some of those found in China, it is more advisable to polish the strips coming from the extruder rather than the tiles after they have already been squared. The reason is that, in the event of breakage during polishing, tiles can still be produced from the strips, whereas, with polishing of tiles already cut to measure, broken pieces can no longer be salvaged.

It was also pointed out that it is possible and less costly to purchase the machinery from various manufacturers. Through this approach, machinery can be acquired which will be increasingly better suited to the kinds of processing desired and to the materials available. On the other hand, however, care must be exercised to see to it that the different segments of the line are properly matched to one another, and greater installation costs must be anticipated.

In any event, a production line such as the one proposed (a diagram of which was left at the Shanghai plant) must operate with blocks of considerable size.

The squaring of the blocks may be omitted, provided they are reasonably regular in shape.

With a facility such as the one recommended, production will vary greatly depending on the type of marble worked and the nature of the blocks used. By working crystalline marble of good hardness and using fairly regularly shaped blocks weighing about ten tonnes, a production capacity of 25 m^2/hour can easily be achieved. On this basis, with an eight-hour daily work shift, output would total some 50,000 m^2 a year. Obviously, this figure could be doubled by introducing two eight-hour shifts a day.

Considering that, for the products in question, the price per square metre on today's international market is about $US 18-20, billing might amount to a minimum of about 900,000 and a maximum of some two million dollars.

The approximate energy requirements of this plant would be the following:

One orthogonal block-cutting machine	150 hp
One squaring machine	15 hp
One splitting machine	120 hp
One continuous-cycle polishing machine	95 hp
One gauging and chamfering machine	20 hp
Small machines	30 hp
Total power	approximately 445 hp

The plant would require the following labour force:

One orthogonal block-cutting machine	1 worker
One automatic unloading device for the above	"
One squaring machine	"
One splitting machine	"

One polishing machine	1 worker
One squaring machine	"
One gauging and chamfering machine	"
Total labour force	7 workers per shift

To this force there should be added two workers for the loading and unloading of the machines; however, at a facility such as the Shanghai plant the operators of the yard crane might assume this function.

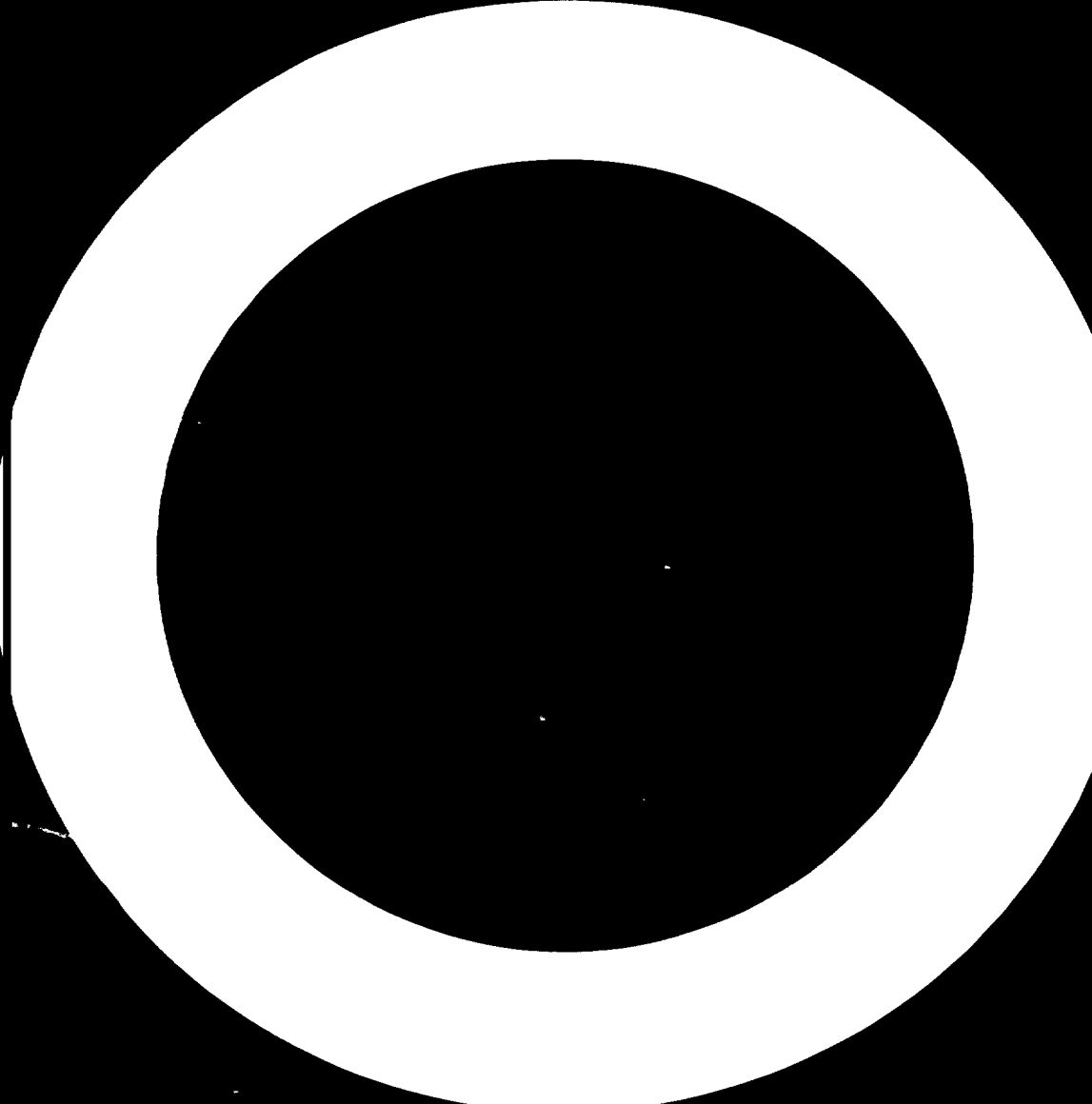
Thus, the work-force should not exceed 14-15 persons for two shifts.

In planning the two plants, a great deal of attention was given to the technical and practical comments of the management and technical personnel of the Shanghai plant, who showed themselves to be very well informed about new techniques and their theoretical aspects.

In the expert's opinion, an opportunity to visit European plants, especially in areas where there is a concentration of marble producers, would enable the Chinese managerial and technical personnel to acquire fresh experience, particularly of a practical nature, in the working of marble and other stones.

The expert would like to thank the Chinese authorities and officials for the courteous attention which they demonstrated during his stay in their country and which helped him greatly in carrying out his mission assignment.

In the event that the Chinese authorities should wish to take up any part of the report in greater detail, the expert will be glad to expand on it at any time.



Annex I

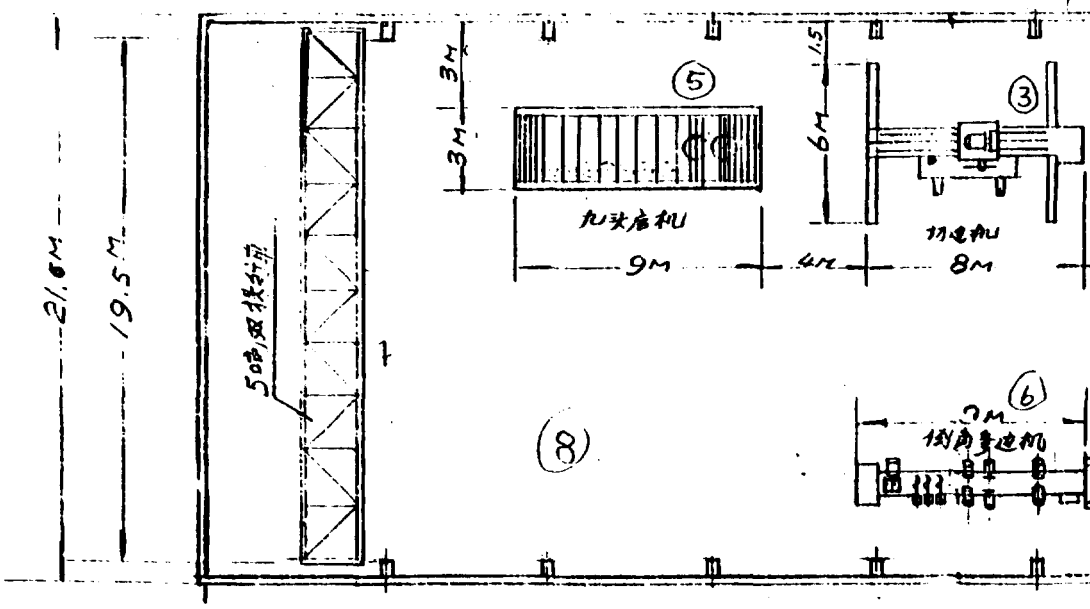
MINISTRY OFFICIALS AND MEMBERS OF THE MANAGERIAL AND TECHNICAL STAFF OF THE SHANGHAI PLANT CONTACTED DURING THE MISSION

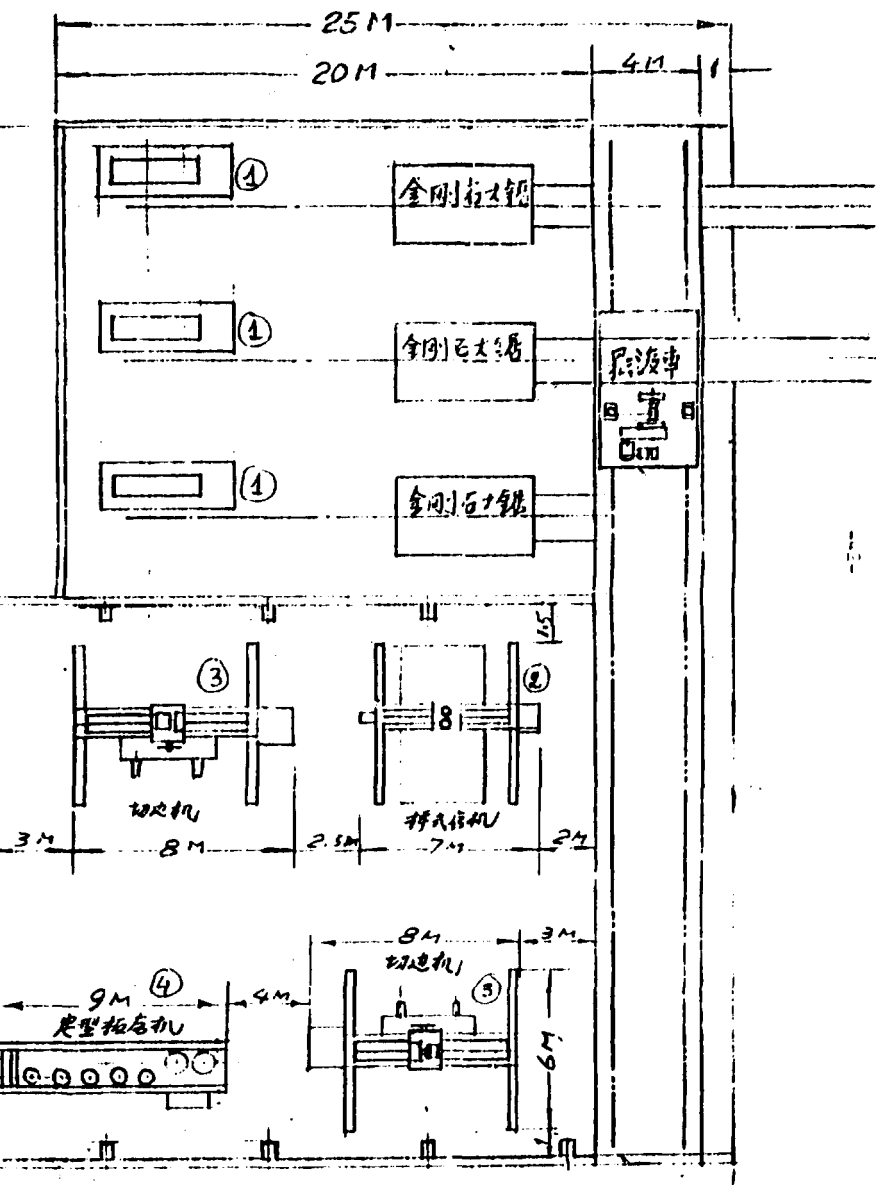
Mr. Liao	Minister of the Building Materials Industry, in charge of the domestic production of marble, granite, and terrazzo
Mrs. Chu	Secretary to Mr. Liao
Mr. She	Director of the Shanghai Plant
Mr. Yen	Assistant Director of the same plant
Mr. Yang	Engineer at the same plant
Mr. Fan	Engineer at the same plant
Mr. Yang	Assistant Director of Corporation No. 2 of the Shanghai Building Materials Industry
Mr. Lui	Officer in charge of foreign affairs at the Administrative Department of the Shanghai Building Materials Industry
Mr. Wang	Engineer, Director at the Administrative Office of Foreign Affairs of the Ministry of Building Materials at Beijing
Mr. Cheng	Director of the administrative section responsible for the domestic production of marble, granite, and terrazzo, under the Ministry of Building Materials at Beijing
Mr. Gao	Assistant Director of the Administrative Office of Foreign Affairs of the Ministry of Building Materials

Annex II

PROPOSED LAYOUT OF WORKSHOP FOR THE MANUFACTURE OF 2 MM AND 3 MM THICK PRODUCTS WITH BRIGHT SURFACE, FROM LARGE-SIZE SLABS

1. Diamond-bladed sawing machine
2. Bridge-type polishing machine
3. Bridge-type cutting machine
4/5. Continuous-cycle polishing machine
6. Edge-polishing machine
7. Five-tonne overhead travelling crane
8. Finishing and packaging area




25M
20M
4M
①
金刚石大锯
①
金刚石大锯
①
金刚石大锯
③
切边机
②
抛光机
3M
8M
2.5M
7M
2M
9M
④
大型抛光机
4M
8M
切边机
3M
⑤
6M